EOS Aura Meeting Registered Attendees
as of 3 September 2003

Doug Allen
Osmo Aulamo

Aura Science Team Meeting
30 September – 3 October 2003
Pasadena, CA

DRAFT AGENDA

Tuesday, 30 Sept 2003

Working Group Meetings - Please arrive early to register

Meteorological Data Products	8:00 a.m. – 11:00 a.m.
Education and Outreach	9:00 a.m. - 11:00 a.m.
Aerosols	11:00 a.m. – 12:00 p.m.
Algorithms	11:00 a.m. – 12:30 p.m.
Validation	1:30 p.m. - 5:30 p.m.
Data Systems	1:30 p.m. – 4:30 p.m.

Aura Science Working Group – Dinner Meeting (Details TBD)

Wednesday, 1 September 2003

7:45 a.m. Registration
8:30 a.m. Welcome
8:35 a.m. Phil DeCola – NASA HQ Program Scientist

9:00 a.m. Project Status
- Project Overview – Rick Pickering
- Long-Term Plan and Mission Ops Status - Carolyn Dent

9:45 a.m. MLS – Joe Waters

10:30 a.m. Break

10:45 a.m. TES – Reinhard Beer
11:30 a.m. OMI – Pieternel Levelt

12:15 p.m. LUNCH

1:45 p.m. HIRDLS – John Gille/John Barnett

2:30 p.m. BREAK and POSTERS

3:30 p.m. Science Talks
- Three-Dimensional Ozone Assimilation in NASA's GMAO: Towards a Multi-Instrument Capability for EOS-Aura (S. Pawson)
- Ozone in Numerical Weather Forecasting (D. Allen)
- Monitoring of Observation Errors of Satellite Ozone Data in Assimilation (R. Rood)
- GOME Tropospheric NO2 with a Retrieval-Assimilation-Modeling Approach (P. Veefkind)
- Characterizing Errors for Data Assimilation (R. Hoffman)

- Constituent Climatologies in Flow-Tracking Coordinates (D. Lary)

5:00 p.m. Adjourn for the Day

Thursday, 2 September 2003

8:30 a.m. Aerosol Working Group Report (S. Massie)

8:45 a.m. Science Talks (continued)
- Vertical Structure in the Tropical Tropopause Layer (W. Read)
- Observations and Implications of Supersaturation in the Presence of Cirrus in the Tropical and Subtropical Upper Troposphere (J. Smith)
- Observations of Boreal Forest Fire Smoke in the Troposphere and Stratosphere (S Massie)
- Influence of Rotational Raman Scattering on the Retrieval of Total Ozone Column Densities Using DOAS Algorithms (P. Veefkind)
- AURA Validation Requirements: Defining the Accuracy of *In Situ* Observations Using Both Advances in Data Reduction Algorithms and Developments in Laser Systems (G. Engel)

10:00 a.m. Break

10:30 a.m. Education and Public Outreach Working Group (S. Stockman)

10:45 a.m. Science Talks (continued)
- Can Dutch Globe Schools Validate MODIS Aerosol Optical Thickness Measurements? (P. Levelt)
- Accuracy and Validation of *In Situ* Water Measurements: Scientific Needs and Satellite Validation (E. Weinstock)
- Identifying Canary Variables (E. Weatherhead)
- Fassst Ring Down Spectroscopy: Measurements of the Atmospheric Absorption Continuum (A. Meshkov)
- AURA Collaborative Science: *In Situ* Airborne Observations That Link Mid-Latitude Ozone Loss and Strat/Trop Exchange (J. Anderson)

12:00 noon Lunch

1:15 p.m. Meteorological Products Working Group Report (G. Manney)
1:45 p.m. Algorithm Working Group Report (N. Livesey)
2:00 p.m. Data Systems Working Group Report (TBD)
2:15 p.m. Validation Working Group Report (L. Froidevaux)
2:45 p.m. Validation Overview (M. Schoeberl)

3:15 p.m. Break

3:30 p.m. Pre-AVE (P. Newman)
4:00 p.m. Tropical Plans (B. Toon)
4:45 p.m. Discussion

Friday, 3 September 2003

8:30 a.m. Science talks (continued)

- Convective Lofting Links Indian Ocean Air Pollution to the South Atlantic Ozone Maximum (R. Chatfield)
- Observations of the Upper Tropospheric Water Vapor Feedback in UARS MLS and HALOE Data (A. Dessler)
- *In Situ* Observational Strategies for Diagnosing Non-Local Control of Water Vapor in the Tropical Tropopause Region (E. Moyer)
- Mean Strat-Trop Transport of Ozone Using EOS MLS Measurements and GCM Vertical Velocities (M. Filipiak)
- Intercomparison of *In Situ* Ice Water Measurements on the WB-57F with Radar Measurements from the ER-2 during CRYSTAL-FACE (D. Sayres)
- Interannual Variations in Transport and Composition in the Tropical Upper Troposphere (D. Waugh)

10:00 a.m. Action Items
Next Meeting

11:00 a.m. ADJOURN

POSTERS

1 Calibration of Toms Radiances from Ground Observations (B. Bojkov)

2 EOS-Aura's Ozone Monitoring Instrument (OMI) Validation (E. J. Brinksma, M. Kroon, R. D. McPeters, P. F. Levelt)

3 The HDF-EOS 5 Aura Profile Standard (Cheryl Craig, Ken Stone, David Cuddy, Scott Lewicki, Pepijn Veefkind, Peter Leonard, Al Fleig, and Paul Wagner)

4 Investigating the role of multiple scattering in HIRDLS observations of cirrus. (G. B. L. Ewen, R. G. Grainger, University of Oxford, Oxford, UK, A. Lambert, H. Lee, NCAR, Boulder, CO)

5 The Development of an Aircraft-Based Instrument to Measure Water Isotopes in the Upper Troposphere and Lower Stratosphere (T. Hanisco)

6 Development of *In Situ* Formaldehyde Sensors for AURA Validation (F. Keutsch)

7 HIRDLS Level 1 to 2 Retrieval Data Processing (Charlie Krinsky)

8 Retrieval Algorithms for the High-Resolution Dynamics Limb Sounder (A. Lambert)

9 Tropospheric Emissions Spectrometer (TES) One Day Test Objectives and Status (M. Lampel (Raytheon), H. Worden, R. Beer, K. Bowman, A. Eldering, M. Gunson, M. Luo, G. Osterman, S. Sund, J. Worden (JPL, CalTech))

10 Detection of Cirrus and Determination of Cloud-Top Pressure by HIRDLS (H. Lee)

11 Inferring Polar Ozone Depletion from Forthcoming ClO Retrievals by EOS MLS (I.A. MacKenzie and R. S. Harwood)

12 Intercomparison of Meteorological Data Assimilation Products during the 2002 Antarctic Winter (G.L.Manney)

13 A New Water Vapor Continuum Model: MT_CKD_1.0 (E. Mlawer (a), S. Clough (a), and D. Tobin (b); (a) Atmospheric and Environmental Research, Inc., (b) University of Wisconsin – Madison)

14 Radiative Transfer Modeling for TES (M. Shephard and S. Clough, Atmospheric and Environmental Research Inc.; D. Tobin, H. Revercomb, and R. Knuteson, University of Wisconsin-Madison; J. Worden, R. Beer, and L. Brown, Jet Propulsion Laboratory; A. Goldman, University of Denver; and C. Rinsland, NASA Langley Research Center)

15 Direct Broadcast Receiving and Very Fast Delivery Data Processing in Sodankylä, Finland (R. Tajakka)

16 Tropospheric Ozone, Tropical Meteorology and Transport: Views from Satellite and SHADOZ (Southern Hemisphere Additional Ozonesondes) (A. M. Thompson)

17 Laser-Induced Fluorescence/Atomic Resonance Scattering Instrument for the Detection of IO, BrO, ClO, ClOOCl, ClONO2, and BrONO2 (D. Wilmouth)

18 Characterization of Aura-TES (Tropospheric Emission Spectrometer) Nadir and Limb Retrievals (H. Worden)

19 Potential Applications of Aura Data in Determining the Influences of Convective Type and Rossby Wave Breaking on Tropical and Subtropical Upper Tropospheric Water Vapor (J. Wright and R. Fu, Georgia Institute of Technology)

20 UARS MLS Cloud Ice Measurements and Implications for H_2O Transport near the Tropopause (D. Wu)

ABSTRACTS (alphabetically by first author)

1. Ozone in Numerical Weather Forecasting (Douglas Allen, Larry Coy, John McCormack, Stephen Eckermann, Naval Research Lab, Washington, DC; Timothy Hogan and Young-Joon Kim, Naval Research Lab, Monterey, CA)

Recent advances in constituent assimilation have allowed the use of 3-D prognostic ozone fields (rather than a 2-D climatology) in numerical weather prediction (NWP). Accurate ozone information can potentially improve forecasts via improved representation of the ozone radiative heating and improved assimilation of TOVS radiances. Here we explore ozone effects on NWP within the framework of the Navy Operational Global Atmospheric Prediction System (NOGAPS), the U.S. Navy's operational global NWP system. We first show prognostic ozone and nitrous oxide fields from a new high-altitude version of NOGAPS and determine the radiative impact of the ozone fields on medium-range forecasts during the period of the 2002 SH major warming. Next, we discuss plans for assimilation of ozone observations into NOGAPS, both using conventional assimilation techniques and by constraining the initial meteorological fields using the strong correlation between ozone and potential vorticity. Finally, we discuss plans for using Aura ozone data to validate NOGAPS prognostic ozone and for testing purposes as we prepare for eventual operational assimilation of Ozone Mapping and Profiler Suite (OMPS) profile and total column ozone data.

2. AURA Collaborative Science: *In Situ* Airborne Observations That Link Mid-Latitude Ozone Loss and Strat/Trop Exchange (James G. Anderson, Thomas F. Hanisco, Richard M. Stimpfle, David M. Wilmouth, Elliot M. Weinstock, Harvard University, Cambridge MA)

A central tenet in the latest WMO report: *Scientific Assessment of Ozone Depletion: 2002* appears in the Scientific Summary for Chapter 4, under, “Attribution of Past Changes in Ozone.” On page 4.2, it is stated:

- “The vertical, latitudinal, and seasonal characteristics of changes in mid-latitude ozone are broadly consistent with the understanding that halogens are the primary cause of these changes, in line with similar conclusions from the 1998 Assessment.”

This position sets the foundation for an important objective of the AURA collaborative science strategy that can be stated as a hypothesis: **The observed long-term trend in mid-latitude Northern Hemisphere ozone in the lower stratosphere over the last two decades is the result of increased catalytic loss of ozone in the lower stratosphere by the rate limiting halogen radicals ClO, BrO, and IO. The observed variability of ozone in the lower stratosphere is the result of factors that modulate those halogen radicals, specifically water vapor, aerosol loading and temperature.**

Understanding the processes governing stratospheric water vapor is broadly recognized as a dominating scientific need. Changes in stratospheric water vapor under future climate regimes would strongly affect both radiative balance and ozone chemistry. In particular, increases in stratospheric water content could dramatically increase ozone losses by (1) increasing the cold aerosol surface area that draws down the NO_x/NO_y ratio thereby increasing the fraction of reactive halogens and hydrogen species portioned into free radical form (ClO, BrO, IO, OH and HO_2); (2) promoting formation of the polar stratospheric clouds on which catalytic ozone loss chemistry occurs; (3) increasing the source of HO_x radicals; and (4) radiative cooling of the lower stratosphere. Because of a lack of measurements, however, debate continues about a wide array of potential scenarios by which air entering the stratosphere is dehydrated. Addressing this issue, closely related to mid-latitude ozone loss, is discussed in terms of the hypothesis: **The boundary condition for water vapor entering the stratosphere in the tropics (irreversible passage through the 390 K surface) is set by the vertical/horizontal temperature structure of the cold trap region over the Western Tropical Pacific through which the quasi-horizontal passage of air provides adequate residence time (coupled potentially with multiple traversals of these cold pools) to desiccate the air to a vapor pressure corresponding to the local, seasonally dependent, temperature minimum.**

A strategy for testing these hypotheses that includes the selection of AURA observations, *in situ* measurements, aircraft and aircraft trajectories, and modeling is presented.

3. GOME Tropospheric NO2 with a Retrieval-Assimilation-Modeling Approach (Folkert Boersma[1], Henk Eskes[1], Pepijn Veefkind[1], and Steffen Beirle[2])

GOME observes several key species of tropospheric chemistry, such as O_3, NO_2, HCHO, BrO and SO_2. These data sets contain important information on aspects like fossil fuel burning emissions, natural hydrocarbon emissions, biomass burning, NO_x produced by lightning, and volcano emissions.

The European Commission GOA project aims to provide long-term series of high-level assimilated GOME data to scientific users. This work focuses on two important aspects of delivering high-quality, quantitative NO_2 columns: (1) the retrieval method, and (2) the error analysis.

(1) Quantitative estimates of tropospheric NO_2 columns are obtained using the three-step DOAS method that obtains a spectrally fitted slant column density, isolates a stratospheric component of the total slant column from the assimilation module, and converts the residual tropospheric slant column into a tropospheric vertical column via a tropospheric air-mass factor.

(2) DOAS column retrieval of tropospheric NO_2 has to contend with a multitude uncertainties related to the satellite instrument and to a priori model parameters. We will present a detailed quantitative error analysis, discussing errors due to the satellite instrument (fitting errors), errors in the estimate of the stratospheric column, and errors in the a priori model parameters (amongst others due to uncertainty in the assumed profile shape) that appear in the tropospheric air-mass factor.

Highlights of the publicly available (www.knmi.nl/goa) total and tropospheric NO_2 product, and a first result of SCIAMACHY NO_2 retrieval will be presented.

[1] KNMI, De Bilt, the Netherlands
[2] University of Heidelberg, Heidelberg, Germany

4. Calibration Of Toms Radiances From Ground Observations (B. R. Bojkov, M. Kowaleski, C. Wellemeyer, G. Labow, SSAI, Lanham, MD; E. Hilsenrath, P. K. Bhartia, NASA GSFC; Z. Ahmad, Science and Data Systems Silver Spring, MD)

Verification of a stratospheric ozone recovery remains a high priority for environmental research and policy definition. Models predict an ozone recovery at a much lower rate than the measured depletion rate observed to date. Therefore improved precision of the satellite and ground ozone observing systems are required over the long term to verify its recovery. We show that validation of radiances from the ground can be a very effective means for correcting long term drifts of backscatter type satellite measurements and can be used to cross calibrate all BUV instruments in orbit (TOMS, SBUV/2, GOME, SCIAMACHY, OMI, GOME-2, OMPS). This method bypasses the retrieval algorithms used to derive ozone products from both satellite and ground based measurements that are normally used to validate the satellite data. Radiance comparisons employ forward models, but they are inherently more accurate than the retrieval algorithms.

This method employs very accurate comparisons between ground based zenith sky radiances and satellite nadir radiances and employs two well established capabilities at the Goddard Space Flight Center, 1) the SSBUV calibration facilities and 2) the radiative transfer codes used for the TOMS and SBUV/2 algorithms and their subsequent refinements. The zenith sky observations are made by the SSBUV where its calibration is maintained to a high degree of accuracy and precision. Radiative transfer calculations show that ground based zenith sky and satellite nadir backscatter ultraviolet comparisons can be made very accurately under certain viewing conditions. Initial ground observations taken from Goddard Space Flight Center compared with radiative transfer calculations has indicated the feasibility of this method. The effect of aerosols and varying ozone amounts are considered in the model simulations and the theoretical comparisons. The radiative transfer simulations show that the ground and satellite radiance comparisons can be made with an uncertainty of less than 1% without the knowledge of the amount ozone viewed by either instrument on ground or in space.

To demonstrate this technique, nadir radiances from Earth Probe TOMS were compared with zenith sky observations over Goddard Space Flight Center from 2001-2003 at three coincident wavelengths (312.5, 317.5 and 360 nm). These comparisons showed good agreement between EP-TOMS radiances corrected by the flight diffuser and by polar ice observations.

5. Convective Lofting Links Indian Ocean Air Pollution to the South Atlantic Ozone Maximum (R. B. Chatfield, Hong Guan, Anne M. Thompson, and Jacquelyn Witte)

We illustrate mechanisms of buildup of column ozone in the equatorial troposphere, specifically describing a possible resolution of the “Atlantic Paradox,” including initial indications of a very long distance contribution from south Asia! Our approach is to describe typical periods of significant maximum and minimum tropospheric ozone for early 1999, exploiting TOMS tropospheric ozone estimates and the SHADOZ (Southern Hemisphere Additional Ozonesondes) ozonesondes. Increases in latewinter Atlantic ozone column follow a characteristic sequence. The sequence starts with biomass burning NOx, which is supplemented, then supplanted, by lightning produced NOx, as the season progresses. The sequence continues with transport from convective to downwind clear regions. Finally, some favored regions of persistent subsidence tend to concentrate ozone locally and downwind. Pollution originating from South Asia can intermittently affect Africa and seems to be associated with the largest South Atlantic ozone peaks.

6. The HDF-EOS 5 Aura Profile Standard (Cheryl Craig, Ken Stone, David Cuddy, Scott Lewicki, Pepijn Veefkind, Peter Leonard, Al Fleig, and Paul Wagner.)

The four instrument teams on Aura have standardized the data format they will use for Level 2 files. This standardization will simplify the development required to use Aura data files. Details of the standard will be presented as well as additional information which end-users will find useful.

7. Observations of the Upper Tropospheric Water Vapor Feedback in UARS MLS and HALOE Data (A. E. Dessler and K. R. Minschwaner)

One of the biggest uncertainties in climate science today concerns the water vapor feedback. Most GCMs hold relative humidity fixed as the climate changes, which provides a strong positive feedback to warming due from anthropogenic greenhouse gas emissions. Some in the community, on the other hand, have speculated that tropospheric specific humidity will remain fixed as the climate changes. Observational studies have attempted to resolve this disagreement, but the results have been inconclusive, and few of the studies have focused on the upper troposphere (UT). This is a significant oversight: the surface temperature is especially sensitive to changes in water vapor in the UT owing to the cold temperatures found there. We present an analysis of UARS MLS and HALOE water vapor measurements at 215 hPa. We find strong evidence that the water vapor feedback in the UT is positive, but not as strong as fixed relative humidity scenarios. This suggests that GCMs are overestimating the sensitivity of the climate.

8. Influence of Rotational Raman Scattering on the Retrieval of Total Ozone Column Densities Using DOAS algorithms (J. F. de Haan, P. Valks, J. P. Veefkind, and P. F. Levelt, Royal Dutch Meteorological Institute (KNMI), De Bilt, The Netherlands, e-mail: haandej@knmi.nl)

Several approaches have been proposed to deal with effects of rotational Raman scattering, also called Ring effect, when DOAS algorithms are used to derive column densities of trace gases.

The first step usually is to obtain a so-called Ring spectrum and include it in the DOAS fit. The Ring spectrum is obtained from polarization measurements of skylight, from convolution of rotational Raman lines with a high-resolution solar spectrum, or from calculations with a radiative transfer code that includes rotational Raman scattering. A significant problem, at least for ozone, is that the Ring spectrum itself depends on the column density of the trace gas, the solar zenith angle, and the viewing direction. One solution might be to create a large look-up table for Ring spectra and to solve the DOAS equation iteratively for the slant column density. However, we propose a much simpler approach which is based on a detailed analysis of the problem, initially for single scattering, but later extended to multiple scattering. The DOAS method is extended so that there are three air mass factors involved, one pertaining to the average ozone path length for elastic scattering, the second pertaining to the path length before Raman scattering, and the third pertaining to the path length after Raman scattering. With these air mass factors correspond three effective absorption cross sections for ozone, two of which are nearly the same. The extended DOAS method is expected to account properly for rotational Raman scattering in the atmosphere. It gives rise to stable DOAS fits, does not require large look-up tables of Ring spectra, and no iteration is required to find the column density.

The extended DOAS method has been applied to GOME spectra, which were modified to resemble the OMI spectral resolution (FWHM = 0.43 nm), thereby reducing errors due to poor knowledge of the slit function and problems due to under sampling. Comparisons were made between results of the extended DOAS method and a DOAS method in which a differential Ring spectrum based on convolution of Raman lines with the solar spectrum was used. Preliminary results show differences up to 8% in the retrieved ozone column density for the two DOAS methods. These differences agree with the differences resulting from sensitivity studies using simulated spectra. The differences depend on the solar zenith angle and might explain at least some of seasonal effects reported for ozone column density produced by the GOME data processor.

9. Can Dutch Globe Schools Validate MODIS Aerosol Optical Thickness Measurements? (Joris de Vroom, Folkert Boersma, and Pepijn Veefkind)

The Dutch GLOBE Aerosol Monitoring Project -part of the OMI E&PO effort- is in the pilot phase since January 2002. After having been trained and instructed, four Dutch high schools are performing routine measurements of Aerosol Optical Thickness (AOT) since that date with the LED-based GLOBE Sun photometer (2 channels with effective wavelengths at 505 and 625 nm).

To investigate the professionally attainable quality of GLOBE Sun Photometer measurements, collocated observations (within 2 m and 60 seconds) with the professional automatic sun-tracking instrument SPUV are performed at KNMI. A comparison involving 138 measurements between September 2002 and March 2003 shows that GLOBE Sun photometer AOT values have a precision better than 0.025 for both channels, but also reveal small systematic errors (<0.02), likely due to calibration errors.

To investigate the quality in practice, 50 GLOBE measurements performed by students from Dutch high school 'De Populier' in The Hague in the February 2002 - March 2003 period, are compared to AERONET AOT measurements from TNO-FEL (less than 4 km and 30 minutes apart) in The Hague. The results of this comparison will be presented, along with the first results of comparisons between collocated MODIS and Dutch GLOBE AOT measurements.

The paper concludes by answering the question whether GLOBE Sun photometer measurements are accurate and precise enough to validate AOT measured by instruments such as MODIS, and later, OMI.

10. AURA Validation Requirements: Defining the Accuracy of *In Situ* Observations Using Both Advances in Data Reduction Algorithms and Developments in Laser Systems (Gregory S. Engel, James G. Anderson, Harvard University, Cambridge, MA)

Data reduction and data analysis algorithms can introduce statistically significant systematic bias and loss of precision in results of both satellite and airborne *in situ* measurement results. Reducing these hidden systematic errors in *in situ* instrumentation is crucial to validating satellite data on a global scale because data from many instruments must be used to create a global mapping. Biases in the *in situ* measurements must be eliminated before credible validation of the remote measurement. Additionally, inter-comparison among satellite and *in situ* instrumentation requires careful review of all collection, reduction and analysis algorithms to eliminate differences in temporal and spatial offsets as well as extrapolation to the appropriate timescales to compare instruments. Typically, the *in situ* community does not archive raw data nor publish retrieval and reduction algorithms in such a way that they can be verified and reviewed; however the validation of remote measurements on a global scale requires this change. In flight inter-comparisons between results obtained from related instruments are necessary but not sufficient to resolve differences in measurements and in uncertainties; details of analysis techniques must also be compared to ensure the agreement or disagreement between instruments is well-understood. Having documented, traceable paths to laboratory calibrations and analysis to flight data will lead to improvements in instrumentation and retrieval algorithms, thereby improving the credibility of atmospheric data. We will show data from Cavity-Enhanced Absorption Spectrometers using Integrated Cavity Output Spectroscopy (ICOS) and Cavity Ringdown Spectroscopy (CRDS) and demonstrate statistically significant improvement in second-generation fitting and retrieval algorithms. Improved lineshape models and singular value decomposition of the baseline have improved internal consistency and precision of the ICOS data, and empirical weighting of the least squares fit has improved retrieval of decay constant from CRDS while removing documented biases from the data. Within this framework, we will analyze the uncertainty in the results from both a theoretical and instrumentation perspective to show how each aspect of the instrument design and algorithm can affect the final result and the uncertainty in that result. Accordingly, Data Analysis and Reduction algorithms should be subject to the same peer review process and documentation process as physical instrumentation.

11. Mean Strat-Trop Transport of Ozone Using EOS MLS Measurements and GCM Vertical Velocities (Mark Filipiak and Ian MacKenzie, University of Edinburgh)

Previous work by Gettelman, Rosenlof and Holton has estimated total stratosphere-to-troposphere transport from UARS MLS measurements using the residual circulation derived from UKMO model fields. We propose to make a similar estimate using EOS MLS measurements and the GMAO or ECMWF models, but simply using the raw vertical velocities from the models, rather than transforming to the residual circulation. We test this simplified method with UARS MLS ozone and UKMO vertical velocities; the results are compared with those estimated using the residual circulation. The use of EOS MLS data will improve the estimates since the ozone data extends to lower altitudes and the horizontal flux from the lower mid-latitude stratosphere to the upper tropical troposphere can now be measured.

12. The Development of an Aircraft-Based Instrument to Measure Water Isotopes in the Upper Troposphere and Lower Stratosphere (Thomas F. Hanisco and James G. Anderson, Harvard University, Cambridge, MA 02138)

The relative abundance of the hydrogen isotopes of water, H_2O and HDO, is a sensitive indicator of the condensation history of an airmass in the upper troposphere and lower stratosphere. It is expected that water isotopes will play a central role in AURA collaborative science and satellite validation experiments, placing an increased need for validation of the *in situ* observations themselves. The observations of the isotopes present a particular challenge because of the very high probability of sampling artifacts in the detection of water vapor itself (Weinstock, this meeting) and the certainty that the isotopes bear those same errors. We will discuss a fluorescence-based instrument that has the sensitivity to measure the relative abundance of H_2O and HDO without the sampling artifacts associated with large sampling volumes. The instrument combines a new water photolysis system with our pre-existing instrument for laser induced fluorescence detection of OH. Water is photolyzed with an excimer lamp source at 172 nm, producing ground state OH and OD radicals that are detected with state selective laser induced fluorescence at 287 nm. The experiment has three notable characteristics. The first is the high sensitivity afforded by laser induced fluorescence detection. At stratospheric mixing ratios of H_2O (4 ppm at 50 mbar), the relative abundance of H_2O and HDO can be measured with a S/N 12 in a 16 s acquisition cycle. The second is a reduction in the exchange of water isotopes on surfaces within the instrument: the OH and OD radicals are removed with near unity efficiency after collisions with walls in the system and are not detected. The third is a rigorous laboratory evaluation of artifacts in the sampling of water vapor and its isotopes, and an empirical demonstration of the instrument’s capabilities. These characteristics enable an independent validation of the absorption based water isotope instruments (JPL ALIAS, HARVARD ICOS) in test flights prior to Aura validation campaigns.

13. Characterizing Errors for Data Assimilation (Ross N Hoffman)

The effective assimilation of TES data will provide a 4-D representation of the chemical structure of the troposphere to improve understanding, monitoring, and prediction of the global environment. The important components of chemistry data assimilation include the hyperspectral data, the species retrieval method, the analysis method, the CTM (chemical transport model), and the data assimilation system used to combine the analysis method and CTM. The data assimilation formalisms require estimates of the background and observation error statistics.

Background error covariances have been developed from CTM forecast pairs using the so-called "NMC method" and are normalized using TRACE-P aircraft data. Error covariances for CTMs are complex. Errors in the meteorological fields, the boundary conditions for emissions, and the chemical mechanism all contribute to CTM errors.

The resulting errors are correlated horizontally, vertically, and between species. They propagate through the CTM by transport and chemical transformations, resulting in further complications. For example, errors in the winds at any single time will at later times produce correlated errors for all transported species. Similarly, errors in emissions or the chemical mechanism will produce correlated errors for chemically coupled species. Also, errors in precipitation will produce correlated errors for water-soluble species, with complicated vertical correlation patterns.

Retrieval error covariances will be developed from the TES one-day test in the end-to-end JPL test bed simulating the measurement and retrieval processes. Individual channels can be chosen which are mostly sensitive to individual species. However, all channels are dependent on the temperature profile, so errors in temperature will introduce correlations between the retrieval errors for the different species. For species retrievals, channels relatively insensitive to water vapor are used. However, there is a continuum water vapor contribution across the spectrum, so errors in water vapor will also introduce correlated species retrieval errors. To the extent that the temperature and water vapor errors are correlated horizontally, the retrieval errors will be as well. The same is true for errors in specifying the temperature and emissivity of the radiative source function. The most transparent channels will see the ground in nadir viewing, but all channels are sensitive to cloud in the line of sight. In addition, vertically correlated temperature and water vapor errors, as well as the retrieval approach will create vertically correlated species amount errors, for those species for which profiles can be retrieved.

14. Development of *in-situ* formaldehyde sensors for AURA validation (Frank N. Keutsch, Thomas F. Hanisco, and James G. Anderson, Harvard University, Cambridge, MA 02138)

Validation of satellite observations of formaldehyde (CH_2O) requires *in-situ* observations of CH_2O with high sensitivity (<10 pptv / sec.) and high vertical and temporal resolution, resulting from the large variation of CH_2O concentrations from the troposphere to the lower stratosphere and the short photochemical lifetime of CH_2O. No routine ground based or *in-situ* correlation data source for OMI validation is presently available that meets these requirements. In addition, *in-situ* measurements of CH_2O are important for a better understanding of photochemistry and CH_2O can be used as a tracer, especially for large-scale convective events. In the latter case the measurement of CH_2O being entrained and detrained from the convective event at all altitudes with instruments optimized for these conditions is of particular interest.

We discuss the development of state-of-the-art CH_2O sensors based on both mid-infrared integrated cavity output spectroscopy (ICOS) and UV laser-induced-fluorescence (LIF) spectroscopy employing novel laser technology. The sensitivities of these two approaches are expected to be 50 pptv / 10 sec. for ICOS and 1 pptv / 10 sec. for LIF, respectively. The compact and light-weight ICOS instrument will be ideally suited for observations in the troposphere whereas the high sensitivity LIF instrument will be used in the upper troposphere and stratosphere, which will also allow a direct comparison of the two instruments. We have developed a calibration method that replaces permeation tubes, which require careful calibration themselves. Instead our CH_2O calibration utilizes a microinjector that introduces a highly repeatable and well-known amount of CH_2O into the detection axis. This method can also be employed during field deployments. The strategy of simultaneous ICOS and LIF detection tied into laboratory and field calibrations will bring the accuracy and quality of laboratory kinetics studies to *in situ* observations and will allow a detailed and fundamentally important analysis of systematic errors.

15. Retrieval Algorithms for the High-Resolution Dynamics Limb Sounder (A. Lambert[1], H. Lee[1], R. Khosravi[1], S. T. Massie[1], J. C. Gille[1,2], D. P. Edwards[1], G. Francis[1], C. M. Halvorson[1], T. D. Eden[1], B. Nardi[1], D. Kinnison[1], W. Mankin[1], M. Coffey[1], and K. Stone[2]

The algorithms for the retrieval of temperature, pressure, ten trace species and aerosol from the HIRDLS 21-channel infrared limb sounder are presented along with a detailed description of the expected error budget composed of measurement noise, forward model error and a priori error.

A 3-D 12-h global-mode set of simulated HIRDLS radiances were generated using atmospheric data at 20-minute intervals from the NCAR MOZART3 model that allows the effects of line-of-sight gradients and diurnally varying species on the retrieval to be investigated

[1] Atmospheric Chemistry Division NCAR
[2] Center for Lower Atmospheric Sounding, University of Colorado, Boulder

16. Constituent Climatologies in Flow-Tracking Coordinates (David Lary)

Constituent climatologies in flow-tracking coordinates together with a description of their salient features are presented. Data from the Upper Atmosphere Research Satellite (UARS) was used. The climatologies are available for download as netcdf files. A new feature of this climatology is the quantification of a suite of uncertainties associated with the climatology all on the climatology grid. This may be useful if the climatology is to be used for *a priori* selection in satellite retrievals. The uncertainties provided with the climatology are: The observational uncertainty as supplied by the instrument teams; the representativeness uncertainty, i.e., the concentration variability over the climatology grid cell; the Kriging uncertainty, i.e., the uncertainty associated with filling in the data gaps; and the total uncertainty due to all of the above.

The preparation of the climatologies led to the highlighting of a downward water tape recorder. Just as there is an annual signal in low water concentrations rising over the tropics there is also an annual signal in high water concentrations descending over the winter poles of each hemisphere. Their absolute value has risen as the chlorine loading of the atmosphere has increased. The increase is correlated with enhanced methane oxidation by chlorine and fit in well with the high latitude time series of methane and HCl observed by the Upper Atmosphere Research Satellite. Up to 1998, on average, the southern upper stratosphere was 2.2% slightly wetter than the northern southern upper stratosphere (NH mean water v.m.r. was 6.03x10-6, SH mean water v.m.r. was 6.16x10-6). This is accompanied by a correspondingly slightly lower average methane and slightly higher average HCl concentration in the south. If a Fourier analysis is done of the polar HCl in the upper stratosphere it is seen that the decline in HCl is approximately 7.5 years later in the south relative to the north.

The regular annual descent in water over the winter poles and the slow increase in water over the 1990s also form a useful test for the realism of coupled chemical transport models.

17. Detection of Cirrus and Determination of Cloud Top Pressure by HIRDLS (Hyunah Lee, Alyn Lambert, Steven Massie, Rashid Khosravi, John Gille, NCAR; Graham Ewen, R. G. Grainger University of Oxford)

The characteristics of cirrus contaminated radiances detected by the HIRDLS infrared limb sounder channels have been analyzed by simulating radiances with varying cloud parameters.

The HIRDLS detectors are in a focal plane arrangement of 7 rows by 3 columns, the detector size is 10 km horizontal by 1 km vertical and the horizontal spacing between the three columns is 17 km and 8 km. Therefore, cloud detection is performed using the best selection from the 7 available detectors for each column.

More than half a million radiance profiles with various combinations of cloud top pressure, thickness, effective radius, and number density were simulated in a wide latitudinal range. Several kinds of cloud detection methods are tested using the simulated radiances. The simulated radiances for the HIRDLS radiometer channels are compared with spectrally integrated observations of cirrus by ENVISAT/MIPAS.

18. Observations of Boreal Forest Fire Smoke in the Troposphere and Stratosphere (Steven T Massie, Alyn Lambert, Hyunah Lee, John Gille, David Edwards, Louisa Emmons (NCAR), Michael Fromm (NRL))

Observations of aerosol in the lower stratosphere during northern summers indicate that aerosol (and by inference, other species) are transported from the lower troposphere into the stratosphere after intense Boreal fires. Observations of Siberian fires in the spring of 2003 are discussed to illustrate how multi-platform data can be used to study these events. MODIS aerosol optical depths, MOPITT CO mixing ratios, TOMS aerosol indices, and POAM aerosol extinction data are used in a joint analysis of the Spring 2003 fires. The fires of 2003 are placed into context to a 20-year record of previous Boreal fire activity. The prospects of analysis of Boreal fire aerosol in the lower stratosphere by the HIRDLS experiment are also discussed.

19. Fassst Ring Down Spectroscopy: Measurements of the Atmospheric Absorption Continuum (Andrey Meshkov and Frank C. De Lucia; Dept. of Physics, Ohio State University, Columbus, OH)

The parameterization of the dry and moist atmospheric absorption continua is important for the satellite retrieval experiments (e.g., AURA MLS). Laboratory measurements of the absolute absorptions of slowly varying phenomena are commonly made by the measurement of cavity Q. We will describe an approach that alternatively determines the cavity losses by a measurement of the ring down time. This approach, combined with a FASSST system, makes possible the measurement of absorption in more than 5000 cavity modes over 100 GHz frequency range in a few seconds. Our essentially simultaneous measurements make possible the observation and elimination of many classes of systematic errors and provide a more direct link to knowledge of the contributions to the uncertainties in the overall retrieval process.

20. A New Water Vapor Continuum Model: MT_CKD_1.0 (E. J. Mlawer[a], S. A. Clough[a], and D. C. Tobin[b]; [a]Atmospheric and Environmental Research, Inc., [b]University of Wisconsin - Madison

For the first time since its inception, a new formulation for the CKD approach to the water vapor continuum has been generated. This new version is designated MT_CKD_1.0. The original CKD formulation, derived in 1980 based upon laboratory measurements due to Burch and collaborators, applied an empirically derived multiplicative factor (different for the self and foreign continua) to the line wing of the impact line shape. This resulted in a line shape that was super-Lorentzian in the near and intermediate line wings and exhibited sub-Lorentzian behavior in the far wings. The self and foreign line shapes were consistently applied to all lines from the microwave to the shortwave, which, when summed, produced the coefficients for the original CKD_0 self and foreign continuum models. This formulation of the CKD continuum was consistent with the interpretation that the water vapor continuum was due to the intermediate and far wings of allowed transitions of the water vapor monomer. In the years since the generation of CKD_0, the continuum coefficients in certain spectral regions have been modified due to new continuum measurements, but the generating functions for the continuum have never been equivalently adjusted. This poster presents the features of the recently released water vapor continuum model MT_CKD_1.0, which utilizes a new formulation of the continuum and is based on the most highly regarded measurements of continuum coefficients, both field- and laboratory-based. The model,s formulation is of a different functional form than the CKD formulation, with the contribution from each spectral line being the sum of two terms: a) a sub-Lorentzian line shape, the product of the impact line shape and a function with values less than unity; and b) a small, broad additional line shape that provides the needed super-Lorentzian absorption in the intermediate line wings. The MT_CKD_1.0 formulation is consistent with the interpretation that the water vapor continuum is due to two distinct effects, the far wings of allowed transitions (dominant in between water vapor bands) and collision-induced absorption (dominant within bands) resulting from the generation of a short-lived dipole moment due to the collision.

Also to be presented will be a discussion of validations of the modifications to the carbon dioxide line shape and associated continuum recently incorporated into the MT_CKD continuum model.

21. *In Situ* Observational Strategies for Diagnosing Non-Local Control of Water Vapor in the Tropical Tropopause Region (E. J. Moyer, D. B. Kirk-Davidoff, E. M. Weinstock, T. F. Hanisco, J. Pittman, J. B. Smith, and J. G. Anderson)

Aircraft missions out of Costa Rica, in the Eastern tropical Pacific, are likely be a significant part of the AURA validation / collaborative science effort, as Costa Rica offers cost-effective access to the tropical tropopause. A major science goal of these flights is understanding the control of water vapor in the near-tropopause region: that is, understanding why and how much it deviates from local saturation. High-resolution aircraft measurements in a restricted area are important for this purpose, but also involve inherent complications. Flights out of Costa Rica in summer 2001 provide a useful lesson that should assist in interpretation of data from upcoming planned aircraft campaigns. The summer 2001 flights showed a distinct mixture of local and remote control on water vapor. The aircraft observed vigorous local deep convection depositing water in the uppermost stratosphere and even beyond it in stratosphere itself, but also sampled much profoundly undersaturated near-tropopause air whose water vapor content was determined elsewhere. Upcoming flights will likely encounter a similar mixture of local and remote control of water vapor, though the processes operating in winter will be very different. In summertime, with a relatively warm tropopause and vigorous deep convection over the tropical E. Pacific, we observed local addition of water via convection. In wintertime, with deep convection in the tropical E. Pacific restricted to lower altitudes, there is no mechanism for raising the water content of air near the tropopause. Flights may instead observe local removal of water via in-situ cirrus formation. In both cases, however, if the aircraft campaigns are to assist in global understanding of the near-tropopause water budget rather than forming only a regional case study, they require a tracer that can provide information about the origin of water vapor in the remotely controlled air. For this reason the isotopic composition of water vapor is a key payload addition. We show how water isotopic composition can diagnose re-wetting of the near-tropopause region by convective detrainment, and can distinguish between cold-trapping in highly localized cold pools vs. in broad-scale uplift. The Harvard group is currently developing a complementary pair of instruments for measurement of water isotopes. The combination allows high-resolution water isotope profiles from the middle troposphere to the lower stratosphere.

22. Vertical Structure in the Tropical Tropopause Layer (W. G. Read, D. L. Wu, J. W. Waters, and H. C. Pumphrey)

Measurements of H_2O in the tropopause region have been obtained by production of a new dataset (V7.02) from the Microwave Limb Sounder (MLS) on the Upper Atmosphere Research Satellite (UARS). The MLS V7.02 data are consistent with slow ascent of tropical H_2O beginning at 147~hPa near the bottom of the tropical tropopause layer (TTL) with a maximum relative amplitude in the seasonal cycle occurring near the tropopause and nearly in phase with the tropopause temperature seasonal cycle. The relative amplitude of the seasonal cycle shows a minimum at 121~hPa in the upwelling moist phase. Seasonal maps show wettest tropical 100~hPa H_2O co-located with continental convection.

23. Intercomparison of *In Situ* Ice Water Measurements on the WB-57 with Radar Measurements from the ER-2 during CRYSTAL-FACE (David S. Sayres, Jasna V. Pittman, Jessica B. Smith, Elliot M. Weinstock, James G. Anderson, Harvard University, Cambridge MA 02138; Gerry Heymsfield and Lihua Li, NASA/GSFC Greenbelt, MD 20771)

One of the major goals of the 2002 CRYSTAL-FACE mission was the intercomparison and validation of remotely sensed quantities such as ice crystal size distributions, ice mass, and water vapor. In order to accomplish this goal, flight plans where the ER-2 overflew the WB-57 during its legs through cirrus were a priority. In this paper a comparison between *in situ* ice water measurements made by the Harvard Total Water and Water Vapor instruments aboard the WB-57 and ice water content retrievals made from the Goddard Cloud Radar System (CRS) aboard the ER-2 is presented using data collected during the CRYSTAL-FACE science mission. This analysis is a first step in determining the necessary requirements to intercompare satellite measurements with *in situ* data. The flight of July 16th, 2003 provided multiple opportunities for direct comparison as the WB-57 flew both directly underneath the ER-2 flight track and through cirrus thick enough to be detected by the radar aboard the ER-2. By using several consecutive passes of the same cloud, we are able to assess the amount of spatial and temporal overlap necessary to achieve a quantitative comparison between the instruments. We find that one must correct for an altitude difference between the altitudes reported by the two aircraft and also account for the movement of the cloud that has occurred in the time interval between the ER-2 overpass and the WB-57 sampling of the cloud. After these corrections are applied, we find good agreement between the two methods of measurement. This methodology can be extended to perform future comparisons between *in situ* data and satellite measurements.

24. Radiative Transfer Modeling For TES (Mark W. Shephard, Shepard A. Clough, Atmospheric and Environmental Research Inc., Lexington, MA; David C. Tobin, Hank E. Revercomb, Robert O. Knuteson, University of Wisconsin, Madison, WI; John Worden, Reinhard Beer, Linda Brown, Jet Propulsion Laboratory, Pasadena, CA; Aaron Goldman, University of Denver, Denver, CO; Curtis P. Rinsland, NASA Langley Research Center, Hampton, VA)

The forward model to be used for the Tropospheric Emission Spectrometer (TES) retrievals of constituents and temperature is built from the Line-By-Line Radiative Transfer Model (LBLRTM). Forward model validations against high quality airborne and surface interferometer measurements demonstrate that the residuals between the calculations and observations are being reduced from "degrees to tenths of a degree". This reduction in forward model systematic error is critical in order to attain the retrieval accuracy capabilities of the next generation of passive remote sensors.

There have been a number of key improvements to the TES forward model that have reduce the systematic errors in the spectral line calculation. The model incorporates the new MT_CKD_1.0 water vapor continuum where the self and foreign water vapor continuum models are each based on the contributions from two components: a collision induced component and a line shape component. The CO_2 line shape and associated CO_2 continuum have been modified and incorporated into the forward model as part of MT_CKD_1.0. CO_2 line coupling is also being investigated and is presently treated to second order at 618, 667, 720, 721, 742, and 792 cm-1 and to first order for CO_2 at the 1932, 2076, 2093, 2193 cm-1 Q-branches. The forward model for the TES absorption coefficients uses a more accurate algorithm for the Voigt line shape function, providing a slight difference on high altitude limb retrievals as the Doppler limit is approached.

Recent improvements in the line parameters have significantly reduced systematic errors associated with the forward model calculation. In order to keep generality for cross-platform comparisons, and incorporate recent spectroscopic line parameter improvements, the TES (tes_v_1.0) spectroscopic line file is built from HITRAN2000 with the updates available as of 08/2003 (last update 09/2001). The TES line file also includes additional updates to CH_4, CO, and 0_3, which are expected to be included in HITRAN updates in the near future. Presented are validations of the TES forward model against aircraft upwelling radiation from the High resolution Interferometric Sounder (HIS) Convection and Moisture EXperiment (CAMEX) and Scanning-HIS ARM/FIRE Water vapor EXperiment (AFWEX), and surface Atmospheric Emitted Radiance Interferometer (AERI) downwelling radiation from the ARM Southern Great Plains (SGP) and North Slope of Alaska (NSA) sites. Also provided is an ozone retrieval that utilizing the improved forward model spectral line parameters and upwelling aircraft observations.

25. Observations and Implications of Supersaturation in the Presence of Cirrus in the Tropical and Subtropical Upper Troposphere (Jessica B. Smith, Elliot Weinstock, Jasna V. Pittman, David Sayres, Elisabeth Moyer, James G. Anderson, Harvard University, Cambridge, MA)

We present *in situ* observations of water vapor and relative humidity with respect to ice, RH_{ice}, in the tropical and sub-tropical upper troposphere obtained aboard the WB-57 aircraft on flights out of Costa Rica during the Clouds and Water Vapor in the Climate System (CWVCS) mission in August of 2001 and out of Key West, Florida during the CRYSTAL-FACE mission in July of 2002. The scientific interpretation of these data depends critically on their accuracy. The Harvard water instrument uses the established Lyman-α photo-fragment fluorescence detection technique to make accurate and precise measurements of water vapor in the vicinity of the tropopause. We frequently observe ice-supersaturation both in clear air and in the presence of cirrus. Our clear air observations show that the summertime upper troposphere over south Florida is supersaturated ~20% of the time. The in-cloud data are normally distributed with a mean supersaturation of 110%. More than 70% of the in-cloud observations have relative humidities greater than 100%. Several factors, from the direct effects of local convection, to mesoscale meteorological processes and variability in aerosol chemical composition will influence clear air and in-cloud relative humidity distributions. We discuss each of these factors, and give careful consideration to the effect of instrumental artifacts and aircraft sampling biases. Flight-to-flight variability in the distributions provides some evidence that ambient aerosol composition, in particular high concentrations of Saharan dust, can affect the nucleation threshold. Moreover, the significant supersaturations measured near the summer tropical tropopause over Costa Rica in combination with the CRYSTAL-FACE data may have implications for the dehydration potential of near tropopause thin cirrus. In general, these data present a substantial contribution to *in situ* observations of clear air and in-cloud relative humidity.

26. Monitoring of Observation Errors of Satellite Ozone Data in Assimilation (Ivanka Stajner[1, 2], Nathan Winslow[1, 3], Richard B. Rood[4], and Steven Pawson[1, 5])

Ozone observations from the Solar Backscatter UltraViolet/2 (SBUV/2) instruments and/or the Earth Probe Total Ozone Mapping Spectrometer (EP TOMS) have been assimilated in near-real time at NASA's Global Modeling and Assimilation Office (GMAO) since January 2000. In this talk we show examples in which this data assimilation system was used as a tool in the monitoring of errors in the incoming ozone observations. The forecast model captures the geophysical variability and produces the forecast fields which can be precisely collocated with the observations. A change in the observed-minus-forecast (O-F) residuals, which are defined as differences between the incoming ozone observations and the collocated short-term model forecast, indicates a change in the assimilation system. If the model and the statistical analysis scheme are stable, then it points to a modification in instrument characteristics or a retrieval algorithm. However, sometimes a change in the ozone O-F residuals is caused by differences in the availability of the meteorological observations or modifications in the meteorological assimilation system whose winds are used to drive the ozone transport model. The O-F residuals are routinely produced and monitored in the assimilation process. Using examples from the NOAA-14 and NOAA-16 SBUV/2 instruments, and the EP TOMS, we demonstrate that the monitoring of time series of O-F residual statistics is an effective, sensitive, and robust method for identifying time-dependent changes in the observation-error characteristics of ozone. In addition, the data assimilation system was used to assist in the validation of updated calibration coefficients for the NOAA-14 SBUV/2 instrument. This assimilation-based monitoring work is being extended to ozone data from instruments on new satellites: Environmental satellite (Envisat), Earth Observing System (EOS) Aqua, and EOS Aura.

(1) Global Modeling and Assimilation Office, NASA Goddard Space Flight Center, Greenbelt, Maryland
(2) Science Applications International Corporation, Beltsville, Maryland
(3) Decision Systems Technologies, Inc., Rockville, Maryland
(4) Earth and Space Data Computing Division, NASA Goddard Space Flight Center, Greenbelt, Maryland
(5) Goddard Earth Sciences and Technology Center, University of Maryland Baltimore County, Baltimore, Maryland

27. Three-Dimensional Ozone Assimilation in NASA's GMAO: Towards a Multi-Instrument Capability for EOS-Aura (Ivanka Stajner[1,2], Krzysztof Wargan[1,2], Nathan Winslow[1,2], Steven Pawson[1,3], Hiroo Hayashi[1,3], Dylan B. A. Jones[4], Richard B. Rood[5])

The original version of the ozone data assimilation system (ODAS) developed at NASA GSFC ingested data from TOMS (total column) and SBUV (total column and partial profiles) instruments. This presentation will discuss updates to the ODAS, especially for the assimilation of limb-sounding data from the UARS-MLS and the Envisat-MIPAS instruments. Other developments of note are the inclusion of parameterized chemistry modules for the stratosphere and troposphere, as well as the on-line implementation of ozone, which will eventually allow for full coupling to the meteorological assimilation system. The focus of the presentation will be on the impacts of including the limb-sounder data on the vertical structure of the assimilated ozone fields: this results in a generally better agreement with independent data from occultation sounders (HALOE, POAM) and ozonesondes. The ozone profile in the lower stratosphere will be critically examined. Impacts on tropospheric ozone columns will be discussed. The assimilation of data from Aura heritage instruments (TOMS, SBUV, MIPAS, and UARS-MLS) prepares us for developing an ozone assimilation system that uses Aura OMI, HIRDLS, and MLS ozone data. The online transport model with a parameterized tropospheric chemistry will provide an improved background for assimilation of TES ozone data.

[1] Global Modeling and Assimilation Office, NASA GSFC
[2] SAIC
[3] GEST, UMBC
[4] Harvard University
[5] Earth and Space Data Computing Division, NASA GSFC

28. Direct Broadcast Receiving and Very Fast Delivery Data Processing in Sodankylä, Finland (Riku Tajakka[1], Osmo Aulamo[1], Anssi Mälkki[2] and Gilbert Leppelmeier[2,3])

The Direct Broadcast Receiving station in Sodankylä, Northern Finland, was built in spring 2003 for receiving OMI data from EOS Aura satellite. The system consist of a 2.4 m dish antenna on top of the newly built receiving station building, control computer, and an integrated processing environment at lower levels of the same building. The system is capable of receiving also X-band Direct Broadcast MODIS data from EOS Terra and Aqua satellites. Operational receiving of MODIS data started in April 2003.

The wide swath of OMI on EOS Aura covers almost all of Western Europe up to the North Pole on one pass that can be received in Sodankylä. The Finnish Meteorological Institute has an agreement with NASA on Aura transmitting Direct Broadcast data daily over Finland. These data will be processed up to Level 2 on-site, and used for nowcasting and prediction of Ozone and surface UV flux levels in Scandinavia, as well as for research purposes.

In this poster we introduce the integrated receiving and processing system, as well as show first MODIS images received in Sodankylä and make predictions for the coverage of OMI in Direct Broadcast mode.

[1] Finnish Meteorological Institute, Arctic Research Centre, Sodankylä
[2] Finnish Meteorological Institute, Geophysics Research, Helsinki
[3] G & S Associates Oy, Espoo

29. Accuracy and Precision in the Southern Hemisphere: Additional Ozonesondes (SHADOZ) Dataset 1998-2000 in Light of the JOSIE-2000 Results (A. M. Thompson, F. J. Schmidlin, J. C. Witte, S. J. Oltmans, and H. G. J. Smit)

A network of 12 Southern Hemisphere tropical and subtropical stations in the Southern Hemisphere ADditional OZonesondes (SHADOZ) project has provided over 2000 profiles of stratospheric and tropospheric ozone since 1998. Balloon-borne electrochemical concentration cell (ECC) ozonesondes are used with standard radiosondes for pressure, temperature and relative humidity measurements. The archived data are available at: <http://croc.gsfc.nasa.gov/shadoz>. In Thompson et al., [JGR, 108, D2: 8238, 2003] accuracies and imprecisions in the SHADOZ 1998-2000 dataset were examined using ground-based instruments and the TOMS total ozone measurement (version 7) as references. Small variations in ozonesonde technique introduced possible biases from station-to-station. SHADOZ total ozone column amounts are now compared to version 8 TOMS; discrepancies between the two datasets are reduced 2% on average.

An evaluation of ozone variations among the stations is made using the results of a series of chamber simulations of ozone launches (JOSIE-2000, Jülich Ozonesonde Intercomparison Experiment) in which a standard reference ozone instrument was employed with the various sonde techniques used in SHADOZ. A number of variations in SHADOZ ozone data are explained when differences in solution strength, data processing and instrument type (manufacturer) are taken into account.

30. Interannual Variations in Transport and Composition in the Tropical Upper Troposphere (Darryn Waugh, Johns Hopkins University)

It is well known that there are large interannual variations in the meteorology of the tropical upper troposphere, particularly over the Pacific. However, the impact of these variations on the tracer transport and the composition of the upper troposphere is not well known. I will present preliminary results examining this issue. Variations in the transport are diagnosed using trajectory calculations driven by analyzed winds. Of particular interest is the lateral mixing of stratospheric and tropospheric air and between convective and non-convective regions, and the dependence of this mixing on the basic flow field. The variations in the transport will be compared with observed variations in upper tropospheric water vapor (from the UARS MLS and HIRS instruments) and total tropospheric ozone (derived from TOMS total column ozone) to identify the role of lateral transport in producing interannual variations in the composition of the upper troposphere.

31. Identifying Canary Variables (E. C. Weatherhead)

Climate change is the focus of many important monitoring programs. Present and planned measurement systems will evaluate changes in a number of environmental parameters, including atmospheric ozone, water vapor, greenhouse gases, and various pollutant species. Identifying clear changes outside of the natural variability in these parameters is often difficult, however, and requires long-term, high quality, stable datasets. Recent research has focused closely on the suggestion of certain parameters as "canary parameters". These variables are suggested as those likely to show clear signs of change earlier than others. A number of factors have been identified to distinguish candidate canary parameters. These factors include a strong signal to noise ratio, a signal large relative to measurement uncertainty, and a clear interpretation of the possible cause of observed changes. Based on these factors, one can determine which of the many proposed environmental changes will likely result in clear signals earlier than others.

32. Accuracy and Validation of *In Situ* Water Measurements: Scientific Needs and Satellite Validation (Elliot M. Weinstock, Jasna V. Pittman, Jessica B. Smith, David Sayres, and James G. Anderson, Harvard University, Cambridge, MA 02138)

Field mission strategies involving *in situ* aircraft must be based on attacking a set of key scientific questions while simultaneously optimizing the quantity and quality of validation opportunities for space-based instrumentation. As we continue mission planning for the next few years, it is the rare scientific question that does not require the measurement of water in one or more of its phases and isotopes. Issues such as strat-trop exchange, trends in stratospheric water vapor, heterogeneous ozone loss, radiative properties of the upper troposphere, and the evolution, lifetime, and radiative properties of cirrus clouds require the accurate measurement of water. Nevertheless, water vapor accuracy issues persist. While measurement differences have been reduced over the last two decades, significant differences remain and are summarized in the December 2000 SPARC assessment of upper tropospheric and stratospheric water vapor. "Significant" means that without resolution of the current instrumental differences, resolution of the science issues is at the minimum strongly impeded, at the maximum nearly impossible. Because of the central role water plays in the chemistry, dynamics, and radiation of the upper troposphere and lower stratosphere, and the many instruments that measure it on various platforms, these instrument accuracy issues must be resolved. We maintain that a protocol must be established that facilitates the independent evaluation of instrument performance and accuracy. While the state of water measurements as presented in the SPARC report invites this evaluation, a protocol established for water should serve as a paradigm for other instrument validations as well. This is a requirement for answering the key scientific questioned being addressed at this meeting and for providing space-based instrumentation with the data quality necessary for proper validation. As an example of *in situ* instrument validation, we summarize here the validation process for our *in situ* water vapor and total water instruments on the WB-57 aircraft. Because of the difference in inlet design and sampling conditions for the two instruments, this process is more extensive and comprehensive than the previous validations for the ER-2 water vapor instrument alone.

33. Laser-Induced Fluorescence/Atomic Resonance Scattering Instrument for the Detection of IO, BrO, ClO, ClOOCl, $ClONO_2$, and $BrONO_2$ (David M. Wilmouth, Richard M. Stimpfle, Thomas F. Hanisco, and James G. Anderson, Harvard University, Cambridge, MA)

The observed long-term trend in mid-latitude Northern Hemisphere ozone in the lower stratosphere over the last two decades may be the result of increased catalytic loss of ozone by the rate limiting halogen radicals ClO, BrO, and IO. These radicals are also important tracers for short-lived halogen compounds that can be used to understand the coupling of the troposphere into and through the TTL. Measurements of these key halogen species can be made *in situ* in the atmosphere with the Harvard Halogen flight instrument, modified to incorporate IO detection capabilities. This instrument was developed for the thermal dissociation / resonance fluorescence detection of $ClONO_2$, ClOOCl, ClO, and BrO. ClO and BrO are detected by the proven technique of chemical conversion followed by resonance fluorescence detection of Cl atoms at 118.9 nm and Br atoms at 158 nm. Modifications to the BrO detection system prior to the SOLVE mission provide substantially improved sensitivity, precision, and spatial resolution relative to previous incarnations of the experiment. Measuring IO *in situ* requires the sensitivity to detect sub parts per trillion concentrations of IO. This level of sensitivity can be obtained using laser-induced fluorescence (LIF) of IO with an approach similar to that of the OH and NO_2 LIF instruments operated in this laboratory. IO will be measured using a solid state Ti:sapphire laser system, which is particularly well suited to IO LIF detection because of its narrow linewidth, high repetition rate, and diffraction limited beam quality. IO radicals will be excited with a single rotational transition chosen to minimize potential interference from NO_2 and O_3, and the fluorescence signal from the 1–0 and 0–0 bands of IO will be detected with a filtered PMT employing time gated photon counting. Ultimately, based on the known laser characteristics of the OH and NO_2 laser systems and the known collection efficiency of the detection optics, we expect a sensitivity of better than 10^5 cm^{-3} for IO.

34. Characterization of Aura-TES (Tropospheric Emission Spectrometer) Nadir and Limb Retrievals (Helen Worden, Reinhard Beer, Kevin Bowman, Annmarie Eldering, Mingzhao Luo, Gregory Osterman, Susan Sund-Kulawik, John Worden[1], Michael Lampel[2], Shepard A. Clough, Mark Shephard[3], Clive Rodgers[4])

The TES Level 2 algorithm retrieves vertical profiles of atmospheric temperature and trace gases from radiometrically calibrated measured spectra. The retrieval is based on minimizing the difference between a measured spectrum and a model spectrum, which is calculated for an estimated atmospheric state. This minimization is subject to smoothness constraints imposed on the atmospheric profiles being retrieved and is applied iteratively using a non-linear least squares solver.

Algorithm descriptions and simulation results are presented. Simulations of the data acquired by TES along different orbit tracks were generated in order to test the TES nadir and limb retrieval algorithms for different spatial and temporal (seasonal and day/night) regimes. Noise added to simulated radiances is representative of the noise measured during TES instrument calibration. Retrieval results, including error analysis and expected vertical resolution, are shown for both the nadir and limb viewing modes of TES.

[1] Jet Propulsion Laboratory, Caltech, 4800 Oak Grove Drive, Pasadena, CA 91109
[2] Raytheon Systems Co, ITSS, 299 N. Euclid Ave., Suite 500, Pasadena, CA 91101
[3] Atmospheric & Environmental Research, Inc. 131 Hartwell Avenue, Lexington, MA 02421
[4] University of Oxford, Atmospheric, Oceanic and Planetary Physics, Clarendon Laboratory, Parks Road Oxford OX1 3PU U.K.

35. Potential Applications of Aura Data in Determining the Influences of Convective Type and Rossby Wave Breaking on Tropical and Subtropical Upper Tropospheric Water Vapor (Jonathon Wright and Rong Fu, Georgia Institute of Technology)

The relative climate scale influences of continental and maritime convection on upper tropospheric (UT) water vapor remains much less clear than the influence of convection type on stratospheric entry mixing ratio. In the last decade, great advancements have been made in our ability to characterize the global distribution of convective system types and the associated temporal variabilities, especially through the use of Tropical Rainfall Measuring Mission (TRMM) precipitation radar (PR) and Lightning Imaging Sensor (LIS) retrievals. Such advancement offers us an unprecedented opportunity to examine the impact of convective system types on the UT water vapor distribution in conjunction with the observations of clouds and water vapor that Aura will provide, especially MLS measurements of water vapor in both cloudy and clear sky. As a prototype of such analyses, we have used TRMM data in conjunction with HALOE water vapor retrievals to explore the relationship between the distribution of convective types and the UT water vapor distribution. We will also examine the physical implications of the observed relationship, particularly, whether they represents the influence of different cloud microphysical properties between maritime-like and continental-like convection on UT water vapor, or merely represents the influence of the frequency of convection, by joint use with ISCCP and MODIS retrievals of cloud effective radius.

Water vapor feedbacks are most sensitive to the driest UT, such as that observed in the subtropical eastern Pacific. Waugh and Polvani (2000) have shown that equatorward incursions of stratospheric air occur frequently over the central and eastern Pacific. The contributions of these stratospheric incursions to the dryness of the UT remains unclear, especially relative to those of the subsidence of air detrained from convective areas. We will use UARS MLS water vapor data to illustrate the potential of Aura data for clarifying this question.

36. UARS MLS Cloud Ice Measurements and Implications for H_2O Transport near the Tropopause (D. L. Wu1, W. G. Read[1], A. E. Dessler[2], S. C. Sherwood[3], and J. W. Waters[1])

UARS MLS (Upper Atmosphere Research Satellite Microwave Limb Sounder) 203-GHz radiances have been used to measure upper-tropospheric and lower-stratospheric (UT/LS) water vapor, a key variable in Stratosphere-Troposphere exchanges. Radiances due to cloud scattering are a significant nuisance to the water vapor measurement, but can be used to obtain cloud ice water content (IWC). A cloud detection and IWC retrieval technique is described here for MLS 203-GHz radiance measurements. Unlike cloud ice retrievals from infrared/visible sensors, this one reflects primarily large ice crystals expected for clouds of convective origin rather for thin cirrus. Though uncertainty in IWC remains fairly large due to poor knowledge of particle size distribution, cloud detection and extracted cloud-induced radiance appear robust. The initial IWC results and comparisons with MLS water vapor measurements reveal many interesting features in the tropical tropopause layer (TTL). The zonal average 100-hPa IWC between 30°S-30°N is found roughly constant at ~0.07 mg/m3, or 0.7 ppmv for equivalent water vapor at this pressure, but large IWCs are concentrated over convective centers where seasonal mean ice content can exceed 20 ppmv vapor equivalent. The correlation between IWC and water vapor at 100 hPa is relatively poor over oceans compared to one over land masses. Overall good correlation exists between tropical IWC and RHi (relative humidity with respect to ice) at 100 hPa during both the dry (January-March) and moist (July-September) periods.

LATE ABSTRACTS (POSTERS)

EOS-Aura's Ozone Monitoring Instrument (OMI) Validation (E. J. Brinksma, M. Kroon, R. D. McPeters, P. F. Levelt)

OMI is a nadir-pointing imaging spectrometer that will measure Earth reflectance and solar irradiance in the 270-500 nm spectral range with a unique spatial resolution of 13 x 24 km (nadir). OMI will contribute to the EOS-Aura mission objectives for climate monitoring and atmospheric research by measuring columns of ozone, nitrogen dioxide, formaldehyde, BrO, OClO, and volcanic SO2, ozone profiles, aerosol optical depth and single scattering albedo, surface UV irradiance, cloud fraction and cloud pressure. These products are retrieved with daily global coverage. The most important objective of OMI is to provide the continuation of the TOMS and GOME total ozone data record.

Four major environmental questions will be addressed by the OMI measurements:
1. Is the ozone layer recovering as expected?
2. What are the sources of aerosols and trace gases that affect global air quality and how are they transported?
3. What are the roles of tropospheric ozone and aerosols in climate change?
4. What are the causes of surface UV-B change?

Extensive validation of OMI is foreseen, based in part on routine ground-based data. However, in view of the high spatial resolution of OMI in combination with the broad spectral range covered and the major environmental questions posed, additional measurements are needed. Existing routine measurements predominantly take place in pristine areas. Therefore, strong needs for additional ground-based and airborne measurements exist (see environmental questions 2 and 3). Examples are measurements of tropospheric ozone and NO2 profiles, to verify the assumptions made in calculating airmass factors for the respective DOAS retrievals, and measurements of aerosol optical properties and scattering behavior in the 340-500 nm spectral range.

We invite the scientific community to submit proposals for validation projects in response to two upcoming simultaneous calls (winter 2003/2004):
1. NASA National Research Announcement for Aura validation (NRA-Aura)
2. International Announcement of Opportunity for OMI validation (AO-OMI)

In the NRA-Aura, US scientists can apply for funding to contribute to Aura validation. The AO-OMI invites the world-wide scientific community (Europe specifically) to participate in the validation of OMI data. Early Aura or OMI data access will be provided to investigators contributing to Aura or OMI validation, respectively. Contacts are Anne Douglass (NRA-Aura: Anne.R.Douglass@nasa.gov) and Mark Kroon (AO-OMI: Mark.Kroon@knmi.nl).

Inferring Polar Ozone Depletion from Forthcoming ClO Retrievals by EOS MLS (I.A. MacKenzie and R. S. Harwood)

The first Microwave Limb Sounder (MLS), aboard the Upper Atmosphere Research Satellite (UARS), operated from 1992 to 2001, measuring inter alia stratospheric ClO and ozone. During the mission a practical method was developed for calculating the rate of chemical ozone loss within the winter polar vortices from the retrieved ClO. Useful results were obtained at a small computational cost, but their full validation was precluded by the absence of an independent measure of the contribution of transport to the observed ozone change. Moreover, the calculation was hampered by certain characteristics of the instrument's sampling pattern.

Earth Observing System (EOS) MLS, the successor to UARS MLS, scheduled for launch in 2004 will have a very different sampling pattern. Hence, the value of repeating the ozone loss calculation (OLC) with the forthcoming EOS MLS retrievals is being investigated. For this purpose a chemical transport model is used, allowing the proposed method to be tested and validated within a fully-known system. The OLC is performed on simulated retrievals from the model atmosphere, and the results so obtained compared with the `correct' answer represented by the actual chemical ozone tendency within the model.

Repeating the calculation under different conditions allows the various sources of error in the vortex-averaged ozone loss inferred from the MLS retrievals to be quantified.

Tropospheric Emissions Spectrometer (TES) One Day Test Objectives and Status (M. Lampel (Raytheon), H. Worden, R. Beer, K. Bowman, A. Eldering, M. Gunson, M. Luo, G. Osterman, S. Sund, J. Worden (JPL, CalTech))

The TES instrument will be launched as part of the EOS Aura spacecraft. The goal of the instrument is to observe important chemical species in the atmosphere, O3, CH4, CO, and others. The TES One Day Test processes 16 orbits (~1day which is defined as a global survey) worth of instrument observations: 1168 nadir target scenes (averages of 2 nadir observations pointing at the same geolocation) and 3504 limb target scenes.

There are four science objectives for the ODT. First, to determine whether the “production mode” implementation of the species retrieval algorithm provides the required accuracy, robustness, and performance needed to be able to successfully process global survey data. Robustness refers to the ability to apply constraints, allow selection of retrieval algorithms and/or cost functions, and include enough detail in the forward model to account for the true variation of the atmosphere so that the majority of target scenes can complete successfully. Second, to determine what information out of the target scene retrievals will be most useful in enabling monitoring of science data quality, instrument performance, and compilation of relevant statistics. Third, to evaluate error analysis techniques for both single target retrievals and aggregations of retrievals, with emphasis on an entire global survey. Fourth, to determine whether ordering target scenes would allow additional improvements in performance.

Status of the ongoing One Day Test will be presented including results of retrievals and corresponding error analyis. The degree to which the above objectives have been satisfied will be discussed.

Intercomparison of Meteorological Data Assimilation Products during the 2002 Antarctic Winter (G.L.Manney(1,2), M.L.Santee(1), D.R.Allen(3), J.L.Sabutis(2), S.Pawson(4), B.Naujokat(5), C.Long(6), C.E.Randall(7), R.Swinbank(8))

The most commonly used meteorological datasets from assimilation systems are intercompared in the context of their representation of processes taking place during the highly unusual southern hemisphere winter of 2002. During that winter, the first major stratospheric warming ever recorded in the southern hemisphere occurred, and many of our intercomparisons will focus on this event. We compare diagnostics to give insight into: transport and mixing, including simulation of lamination in trace gas observations and using effective diffusivity to examine global mixing and transport barriers; temperatures and temperature evolution related to PSC formation; and wave propagation and the use of these datasets to drive a mechanistic model. The datasets compared here include NASA's GEOS-4 analyses, and the UK Met Office, ECMWF, NCEP/CPC, and NCEP/NCAR Reanalysis analyses. We show significant differences between analyses in many diagnostics that may be important to studies of polar processes and stratospheric sudden warmings. The NCEP/NCAR reanalysis data stand out as an outlier in many diagnostics; therefore caution is advised in using those data in studies of the lower to middle stratosphere.

Investigating the role of multiple scattering in HIRDLS observations of cirrus. (G. B. L. Ewen, R. G. Grainger, University of Oxford, Oxford, UK, A. Lambert, H. Lee, NCAR, Boulder, CO)
Radiances detected by HIRDLS are particularly sensitive to the presence of thin cirrus. Furthermore, in the presence of cirrus, the detected radiances can be significantly enhanced by the scattering of tropospheric radiation into the field-of-view.

The effect of multiple scattering was investigated by comparing simulated HIRDLS radiances with and without scattering included. Simulations were completed for cirrus of varying cloud top height, thickness and effective radius. These simulated radiances were also compared to spectrally integrated observations of cirrus from ENVISAT/MIPAS.

Multiple scattering was included in the simulated radiances by using a reverse method three-dimensional Monte Carlo transfer model in the cloud domain.

With further work the scattering enhancement in detected radiances can be adequately accounted for in the HIRDLS cloud detection method.

Tropospheric Ozone, Tropical Meteorology and Transport: Views from Satellite and SHADOZ (Southern Hemisphere Additional Ozonesondes) Anne M. Thompson, Jacquelyn C. Witte, Robert B. Chatfield, Hong Guan NASA/GSFC/Code 916, Greenbelt, MD 20771)
Two datasets have been used to study tropospheric ozone in the tropics during the period 1998-2002. Satellite data, the modified-residual TTO (tropical tropospheric ozone) product from the TOMS instrument (http://www.atmos.umd.edu/~tropo), give column tropospheric ozone amounts in Dobson Units over the entire tropical band. SHADOZ ozone soundings (http://croc.gsfc.nasa.gov/shadoz>) give weekly profiles at a dozen stations distributed zonally

throughout the southern tropics [Thompson et al., 2003]. Geographical variability (differences between Atlantic and Pacific stations, for example) and short-term temporal variations at individual sites are the most characteristic feature of the observations. AURA data products need to be sufficiently well-resolved to capture these features. Examples are shown from among the following: the zonal wave-one feature in tropospheric ozone; evidence for inter-continental scale transport of ozone resulting from biomass burning; interaction of ozone with convection which is especially pronounced in areas affected by the Asian winter monsoon.

Two Dimensional Characterization of Atmospheric Profile Retrievals From Limb Sounding Observations (John Worden)
Limb sounders measure atmospheric radiation that is dependent on atmospheric temperature and constituents that have a radial and angular distribution in Earth-centered coordinates. In order to evaluate the sensitivity of a limb retrieval to radial and angular distributions of trace gas concentrations, we perform and characterize one-dimensional (vertical) and two-dimensional (radial and angular) atmospheric profile retrievals. Our simulated atmosphere for these retrievals is a distribution of carbon monoxide (CO), which represents a plume off the coast of south-east Asia. Both the one-dimensional (1D) and two dimensional (2D) limb retrievals are characterized by evaluating their averaging kernels and error covariances on a radial and angular grid that spans the plume. We apply this 2D characterization of a limb retrieval to a comparison of the 2D retrieval with the 1D (vertical) retrieval. By characterizing a limb retrieval in two dimensions the location of the air mass where the retrievals are most sensitive can be determined. For this test case the retrievals are most sensitive to the CO concentrations about 2 degrees latitude in front of the tangent point locations. We find the information content for the 2D retrieval is an order of magnitude larger and the degrees of freedom is about a factor of two larger than that of the 1D retrieval primarily because the 2D retrieval can estimate angular distributions of CO concentrations. This 2D characterization allows the radial and angular resolution as well as the degrees of freedom and information content to be computed for these limb retrievals. We also use the 2D averaging kernel to develop a strategy for validation of a limb retrieval with an in-situ measurement.

HIRDLS Level 1 to 2 Retrieval Data Processing (Charlie Krinsky)
The HIRDLS instrument onboard the NASA EOS Aura satellite is scheduled for launch in the first half of 2004 and will measure 10 atmospheric species (O_3,H_2O,NO_2,N_2O_5,HNO_3,CFC11,CFC12,N_2O, and $ClONO_2$) along with temperature, pressure, and aerosols in 4 spectral regions. The L1 processing of the HIRDLS software processing is being developed at Oxford University, United Kingdom, and the L2 processing is being developed in Boulder, Colorado as a joint effort of the University of Colorado and the National Center for Atmospheric Research. The HIRDLS L1 to L2 software system converts raw radiances from the HIRDLS IR radiometer into geophysical parameters and is composed of the L2 Preprocessor and the L2 Processor developed in C++ and Fortran90 respectively. Data preparation for the retrieval and the post processing of retrieval output is the subject of this poster. This includes preparation of a-priori and climatology inputs, performing the line of sight gridding, filling all data structures as required by the retrieval algorithm, and transforming from a vertical altitude grid to a pressure grid as specified for Aura Level 2 products. This results in the final Level 2 HIRDLS product to be used for validation and science.